Microcontroller Uses and Standards in Modern Automobiles

Introduction

With the onset of increasingly complex electrical systems, applications, and processing needs, the use of microcontrollers to handle operations has also increased significantly. Microcontroller applications are found in managing various electrical networks ranging from large equipment such as air conditioning units, mainframe computers, and airplane navigation systems, to smaller devices such as cell phones, PDAs, and digital watches. In particular, the presence of microcontrollers in automobiles plays an important role in automotive electronics, as evidenced by the presence of 25 to 35 electronic control units (ECUs) in the typical Ford vehicle. In luxury cars, such as the BMW 7 Series, the number of ECUs can range from 60 to 65 [1]. Microcontrollers manage ECU functions such as braking, steering, power windows and seats, headlights and taillights, and safety-checking to monitor other active microcontrollers. This paper reviews the current technological relationship between microcontrollers and automobiles as well as the standards and physical goals set by companies that manufacture such products.

Automotive Microcontroller Functions

Microcontrollers in cars establish a means by which ECUs can communicate with one another through multiplexing. Microcontrollers can then manage related systems autonomously by using a common bus to communicate messages to other networks when they are needed to perform a function [2]. The combination of multiple linked networks comprises the Controller Area Network (CAN). Since the first CANs developed in the 1980s by German engineer Robert Bosch [3], modern CANs allow complex interactions such as those involved with sensory systems where car speed, in-car temperatures, and outdoor rainfall interact in real time with performance controls for braking mechanisms, air-conditioning maintenance, and the audio-visual multimedia systems [2]. The communications established throughout the car by these microcontrollers has led to both automotive fault-tolerant and fail-safe systems, where not only can microcontrollers serve to counteract faults and mishaps that occur to the car (e.g. broken lights, accelerator and anti-lock brake interference), but they may also duplicate as secondary units that constantly check the primary microcontroller in the event that the microcontroller itself fails. An example of fault-tolerance occurs when car tires slip on a snow-filled road. The event not only triggers a response from the driver, but the occurrence is also noticed by a sensor microcontroller, which will then activate the anti-lock braking system when the driver slams on the brakes [3].

Competitive Standards for Automobile Microcontrollers

Fundamentally, all microcontrollers require a chip that contains a CPU, program memory, random-access memory, and programmable inputs and outputs. Modern microcontrollers that enhance
control of automobiles range from 8-bit to 32-bit Harvard architecture with high performance, low cost CPUs and efficient data storage in memory [1]. Due to the need for fast throughput alongside the occupation of minimal chip space, the Reduced Instruction Set Computing (RISC) is preferred as industrial CPU standard. Current CPUs, such as the ones used in the Piccolo microcontrollers by Texas Instruments, have an efficient clock speed of up to 60 MHz while processing code in the range of 40 to 60 million instructions per second (MIPS) [4].

The requirements for a microcontroller’s different memory arrays depend on the function of memory as either a program storage mechanism or as a temporary allocation for the program’s call-stack. Though no research has indicated that RAM will be replaced as a medium for short-term memory, the Flash EEPROM’s (electronically erasable programmable read-only memory) ability to be electronically erased and rewritten with new data and calibration standards has taken over as the preferred choice for data memory over ROM (read-only memory) [1]. Though cheaper, ROM is inefficient when revising microcontroller functions, as it must be replaced each time the user wishes to program new microcontroller algorithms. Alongside efficiency comes durability, as Flash EEPROMs can have guaranteed data retention for up to 20 years at 55 °C [5].

Physical Achievements and Goals

The robustness and efficiency of microcontrollers have increased in response to industrial demands for smaller microcontrollers. Smaller microcontrollers not only increase the mobility of microcontroller placement in the car, but the smaller the microcontroller, the lower the amount of voltage needed to power the chip. The standard operating voltage for automotive microcontrollers is currently 3.3 V with maximum output currents of 20 mA according to the specifications of the TI Piccolo microcontrollers, whose 19 x 19 mm area houses up to 80 I/O pins [4]. This popular family of microcontrollers also includes the preferred CPUs and data memory devices previously mentioned. With an increased market volume by 63% in the past four years for more robust microcontrollers to handle hybrid and electric vehicles [6], the drive to reduce human error continually creates new challenges for manufacturers to develop even smaller, more powerful, and more efficient microcontrollers.

References


